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COLOSSAL CYTOTOXIC POTENTIAL OF THE WONDER HERB, *OCIMUM*: A REVIEW

[*1]Sumitha K V and [2]Dr. John E Thoppil

[1]Research Scholar, Cell and Molecular Biology Division, Department of Botany, University of Calicut, Kerala, India, 673635.

[2]Professor, Cell and Molecular Biology Division, Department of Botany, University of Calicut.

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***Correspondence for Author**
Sumitha K V
Research Scholar, Cell and Molecular Biology Division, Department of Botany, University of Calicut, Kerala, India, 673635.

ABSTRACT

In the present review, an attempt has been made to congregate the cytotoxic property of *Ocimum*, a medicinal herb used in indigenous system of medicine. This medicinal herb is considered as a sacred plant by the Hindus in the Indian subcontinent. Scientific explorations based on traditional medicinal properties of *Ocimum* (tulsi) have got momentum mostly after the middle of the 20th century. Most of these evidences are based on *in-vitro*, experimental and a few human studies. Studies in biological models provide proof for its anticancer activity. Since tulsi exhibit anticancer activity in animal models, studies were carried out in human cancer *in vivo*, *viz.*, human cell fibrosarcoma and *in vitro* in human cervical cancer cell line (HeLa) and human laryngeal epithelial carcinoma cell line (HEp-2) and it was found to be effective. Studies were found to correlate the cytotoxic potential with anticancer activities. Thus, this review is a concise version of cytotoxic effect of *Ocimum*. Evaluating the potential cytotoxic and genotoxic effects of plant extracts is essential for standardization of the herb, not only forsafety purposes, but for determining its dosage and to understand the mechanism and broad range of action of these herbs. Therefore, it is worthwhile to review its cytotoxic properties to give an overview of its status to scientists, both modern and Ayurvedic.

KEYWORDS: *Ocimum*, cytotoxicity, anticancer.

INTRODUCTION

Plants have formed the basis of sophisticated traditional medicine systems that have been in existence for thousands of years and continue to provide mankind with new remedies (Fakim 2006). They have provided and will continue to provide not only directly usable drugs, but also a great variety of chemical compounds that can be used as starting points for the synthesis of new drugs with improved pharmacological properties. The important advantages claimed for therapeutic uses of medicinal plants in various ailments are their safety usage, besides being economical, effective and also their easy availability (Atal 1989; Siddiqui 1993). Because of these advantages the medicinal plants have been widely used by the traditional medical practitioners in their day to day practice.

Cancer still remains as a leading cause of death in economically developed countries and ranks second in developing countries. A wide variety of secondary metabolites obtained from plants are tested for their ability to treat cancer. Various anti-cancer drugs from plants are known to be effective against proliferating cells. Genotoxicity studies are designed to determine chemicals that can perturb genetic material causing gene or chromosomal mutations. Genotoxicity test results are usually taken as indicators for mutagenic effects. Various chromosome disturbances and drastic effects on cell division, in addition to chromosome breaks are important for a better understanding of the action of any substance. They exhibit cytotoxic effects either by damaging DNA or by blocking the formation of mitotic spindle during stages of cell division (Muhtasib and Bakkar 2002). However most of the cytotoxic drugs exhibit side effects and hence, there is a need for drugs that are efficient and have less side effects (Powis 1983). The use of plant products in the treatment of cancer has been of recent interest (Bauer 2000). Results of the studies on cytotoxicity indicate that *Ocimum* L. possesses antitumor properties and may serve as a potential source for investigation and development of anticancer drugs. The present review aims at evaluating the cytotoxicity of *Ocimum*.

Genus *Ocimum*

Ocimum is a genus of about 35 species of aromatic, annual and perennial herbs in the family Lamiaceae, mostly native to the tropical and warm temperate regions of the Old World, commonly called as basil or tulsi. The name tulsi is derived from Sanskrit, which means “matchless one”. It has made important contribution to the field of science from ancient times as also to modern research due to its wide spectrum of medicinal properties. The plant is

distributed and cultivated throughout India. It is an erect, much branched, fragrant plant attaining a height of about 30-60 cm when mature. Its aromatic leaves are simple, opposite, elliptic, oblong, obtuse or acute with entire or sub serrate or dentate margins, growing up to 5 cm long. The flowers of *Ocimum* are small, purplish in elongate racemes in close whorls. The fruits are small and the seeds are reddish-yellow in colour. The plant is bitter and acrid (Das and Vasudevan 2006; Prajapati et al. 2003).

Health benefits of basil (Tulsi)

The health benefits of holy basil or tulsi include oral care, relief from respiratory disorders, fever, asthma, lung disorders, heart diseases and stress. Holy basil (*Ocimum tenuiflorum*) or tulsi is undoubtedly the best medicinal herb ever known. It has endless miraculous and medicinal values and is being worshipped in India since thousands of years. A few leaves dropped in drinking water or food stuff can purify it and can kill germs in it. Holy Basil is so good for boosting up the immune system. It protects from nearly all sorts of infections from viruses, bacteria, fungi and protozoa. Recent studies show that it is also helpful in inhibiting the growth of HIV and carcinogenic cells (Kumar et al. 2012).

Traditional uses

Tulsi is also known as "the elixir of life" since it promotes longevity. Different parts of the plant are used in Ayurveda and Siddha systems of medicine for prevention and cure of many illnesses and everyday ailments like common cold, headache, cough, influenza, earache, fever, colic pain, sore throat, bronchitis, asthma, hepatic diseases, malarial fever, as an antidote for snake bite and scorpion sting, flatulence, migraine headaches, fatigue, skin diseases, wound, insomnia, arthritis, digestive disorders, night blindness and diarrhoea. The leaves are good for nerves and to sharpen memory. Chewing of tulsi leaves also cures ulcers and infections of mouth (Prajapati et al. 2003).

Ocimum tenuiflorum L. (Holy basil), *O. gratissimum* L., *O. americanum* L. (Hoary basil), *O. basilicum* L., *O. kilimandscharicum* Gurke (Camphor basil), and *Ocimum campechianum* Mill. (Amazonian basil) are some of known important species of genus *Ocimum* which grow in different parts of the world and are known to have medicinal properties.

Ocimum tenuiflorum (syn. *O. sanctum* L.) also known as Tulsi or Holy basil, is an aromatic plant in the family Lamiaceae which is native throughout the old world tropics and

widespread as a cultivated plant and an escaped weed (Staple and Kristiansen 1999). It is an erect, much branched sub shrub 30–60 cm tall with hairy stems and simple opposite green leaves that are strongly scented. Leaves have petioles, and are ovate, up to 5 cm long, usually slightly toothed. Flowers are purplish in elongate racemes in close whorls (Warrier 1995). There are two main morphotypes cultivated in India *viz*., green-leaved (Sri or Lakshmi tulsi) and purple-leaved (Krishna tulsi) (Kothari et al. 2005). It possess antioxidant properties (Balaji 2002) and also used in memory improvement (Joshi and Parle 2006).

Ocimum basilicum commonly known as sweet basil, is an erect, almost glabrous herb, 30-90 cm. high, Leaves ovate-lanceolate, acuminate, toothed or entire glabrous on both surfaces, glandular; flowers white or pale purple, in simple or much branched racemes, often thyrsoid; nutlets ellipsoid, black pitted. *O. basilicum* var. thyrsiflora, or Thai basil, is a common ingredient in Thai cuisine, with a strong flavour similar to aniseed, used to flavour curries and stir-fries (Mirdha and Mahapatra 2009). It has been used as a folk remedy for an enormous number of ailments, including boredom, cancer, convulsion, deafness, diarrhoea, epilepsy, gout, hiccup, impotency, insanity, nausea, sore throat, toothaches, and whooping cough. Basil has been reported in herbal publications as an insect repellent (Sullivan 2009).

Ocimum gratissimum also known as African basil or Clove Basil; Pale yellow flowers, tall, branched herb, 1- 2.5 m height. Leaves ovate, coarsely- crenate, gland dotted, pubescent in both surface; flower pale greenish yellow, in simple or branched racemes, moderately close whorled; nutlets sub- globose, rugose, brown, with glandular depression, not mucilaginous. Essential oil and extracts of *O. gratissimum* possess antibacterial (Silva et al. 2010), antidiabetic (Tanko et al. 2007), antitumor, anti-cancer (Ekunwe et al. 2010), anti-fertility (Obianime et al. 2010), hepatoprotective (Arhoghro et al. 2009) and analgesic activities (Iroanya et al. 2009), used against gastrointestinal disorders (Madeira et al. 2002) and diarrhoea (Veronica et al. 1999).

Ocimum kilimanscharicum (syn. *O. tortuosum* Baker) is an economically important medicinal perennial herb that is widely distributed in East Africa, India and Thailand. It is extensively grown in the tropics (Soumen et al. 2010). Leaves ovate or oblong, acute narrow at base, deeply serrated, pubescent on both surfaces; flowers in 4-6 flowered whorls on long villose racemes; nutlets ovoid to ovoid oblong, black to brown.

Ocimum americanum (syn. *O. canum*) is a native of tropical Africa. It is known as lime, hairy or hoary basil. It is an annual herb, 30- 60 cm height with white or lavender flowers. Leaves elliptic- lanceolate, entire or faintly toothed, almost glabrous, gland dotted; flowers small. It is used for medicinal purposes. The aerial parts of *O. americanum* contain volatile oil, flavanoids, carbohydrates, phytosterols, tannins and fixed oils (Sarma and Babu 2011).

Ocimum campechianum (syn. *Ocimum micranthum* Wild.) is a South American variety often utilized in ayahuasca rituals for its smell which is said to help avoid bad visions (Steele 2006). It possesses antibacterial, antiprotozoal and antioxidant activity (Navarro et al. 2003).

Cytotoxic activities of *Ocimum*

Most of the synthetic compounds used for killing cancer cells may have cytotoxic effects towards normal cells. Hence, nowadays the focus is on natural products for causing the apoptosis. The study of many types of neoplasia and their possible therapy using natural compounds forms the basis of much of the research nowadays (Jha et al. 2010). Recently, medicinal plants have emerged as attractive candidates for cancer chemoprevention because of their safety, relative to synthetic cytotoxic agents (Park and Pezzuto 2002). It was found that the ethanolic extracts of *O. sanctum* cause apoptosis in SiHa cells. The IC_{50} values were determined using the cell proliferation assay, MTT assay. The study concluded that, the tested plant extracts contain natural compounds which do not have any cytotoxic effects on normal cells (Jha et al. 2012).

Kathirvel and Ravi (2012) conducted studies to identify the chemical composition and *in vitro* anticancer activity of the essential oil from *O. basilicum*. A methyl thiazol tetrazolium assay was used for *in vitro* cytotoxicity screening against the human cervical cancer cell line (HeLa), human laryngeal epithelial carcinoma cell line (HEp-2) and NIH 3T3 mouse embryonic fibroblasts. The IC_{50} values obtained were 90.5 and 96.3 µg/ml, respectively, and the results revealed that basil oil has potent cytotoxicity.

James et al. (2008) in their study focused on a comparative evaluation of the antioxidant capacities and cytotoxicity of two *Ocimum* species (*O. gratissimum* and *O. basillicum*). The cytotoxicity to brine shrimps showed that the LC_{50} (lethal concentration) of the plant extracts were higher than that of the reference standard (Potassium dichromate) indicating low toxicity. The extracts of *O. basilicum* appears to be more toxic than *O. gratissimum* when

both were compared to the reference standard. These two *Ocimum* species possessed very low cytotoxicity to brine shrimps and are relatively safe for the purpose utilized.

Debnath and Hussain (2013) demonstrated that crude extracts of *O. sanctum* has got intense *in-vitro* cytotoxic effect and may have potential use in traditional medicine. In this study the leaves of *O. sanctum* was extracted with organic solvent (methanol) and the extracts were fractionated by using solvent-solvent partition. The n-hexane, ethyl acetate, and chloroform soluble fractions of methanolic crude extract of *O. sanctum* were screened for cytotoxic activity using brine shrimp lethality bioassay. A reputed cytotoxic agent, vincristine sulphate was used as a positive control. From the results of the brine shrimp lethality bioassay it was well predicted that n-hexane, ethyl acetate, and chloroform soluble fractions of methanolic crude extracts possess cytotoxic principles in comparison with positive control, vincristine sulphate.

Borooah (2011) in his study used aqueous leaf extract of *O. gratissimum* to investigate its cytotoxic and genotoxic effects on root meristematic cells of *Allium cepa*. It was found that leaf extract of *O. gratissimum* exhibits mitodepressive activity. Mitodepressive activity was found to be maximum at higher concentrations. Of all the concentrations used in the study, 5% concentration of leaf extract induced maximum genotoxicity leading to the formation of sticky chromosome, c-metaphase, metaphasic and anaphasic disorders while 20% concentration showed binucleate cells. Finally, it was concluded that high concentration of *O. gratissimum* leaf extract shows cytotoxic and genotoxic activities.

Treatment with ethanolic extract of *O. sanctum* induced cytotoxicity at 50 µg/ml and above (Karthikeyan et al. 1999). Kathirvel and Ravi (2012) in their research employed methyl thiazol tetrazolium (MTT) assay, a simple and reliable technique, which measures cell viability for screening the cytotoxic activity. The viabilities of cancer cells after incubation with different concentrations of *O. basilicum* essential oil are reported in HeLa cell line, HEp-2 cell line and NIH 3T3 normal cell line and percentage of cell inhibition was plotted versus concentrations of oil sample. Data showed that incubation with different concentrations of oil affected the viability of human cervical cancer cell line (HeLa), human laryngeal epithelial carcinoma cells (HEp-2) and NIH 3T3 mouse embryonic fibroblasts. The oil sample showed cytotoxic effect on the HeLa, HEp-2 and NIH 3T3 cell lines in a dose-dependent pattern.

Oyedare et al. (2009) conducted an experiment at tested concentrations of aqueous extract of *O. gratissimum* at the two time intervals of 24 and 48 h, there was a concentration dependent reduction in the mitotic index of root tip cells of *A. cepa* when compared with the control. The mitotic index (MI), which is used as an indicator of adequate cell proliferation biomarkers, measures the proportion of cells in the M-phase of the cell cycle and its inhibition could be interpreted as cellular death.

The anticancer activity of *O. sanctum* has been reported against human fibro-sarcoma cells culture, wherein *AlE* of this drug induced cytotoxicity at 50 mg/ml and above. The ethanol extracts of *O. sanctum* exerted cytotoxicity against Lewis lung carcinoma (LLC) cells (Verma and Kothiyal 2012). In a study (Magesh et al. 2009), apoptotic mechanism of ethanol extracts of *O. sanctum* was investigated in A549 cells *in vitro* and in the LLC (Lewis lung carcinoma) tumor model *in vivo*. The ethanolic extract exerted cytotoxicity against A549 cells, increased the sub-G1 population and exhibited apoptotic bodies in A549 cells.

The cytotoxic activity of the isolated essential oil of *O. canum* was tested against breast cancer cell lines (MCF-7) using MTT assay and significant cytotoxicity (IC_{50} value of 60 µg/mL) and DNA fragmentation was observed (Selvi et al. 2012). Sharma *et al*. (2010) investigated the apoptosis inducing effect of the essential oil (EO) from aerial parts of *O. viride* in human colorectal adenocarcinoma cells (COLO 205 cell line). EO is cytotoxic to COLO 205 cells in dose and time-dependent manner, as is evident by SRB assay. Their results reveal that EO has apoptosis inducing effect against COLO 205 cells *in vitro* and is a promising candidate for further anti-cancer study.

Mahapatra et al. (2009) studied the cytotoxic effect of *O. gratissimum* in murine peritoneal macrophages at different concentrations using the 3-(4, 5-dimethylthiazol-2-yl)-2, 5 diphenyltetrazolium bromide (MTT) method, and it was found that they does not induce significant cell cytotoxicity. In a study conducted by Sharma et al. (2011) revealed the selective anti-proliferative effect of *Ocimum* on human cancer cells. Sundaram et al. (2011) used SRB assay to test *in vitro* cytotoxicity of six Indian medicinal plant species against four human cancer cell lines. These plants are being used by traditional people in tribal regions for treatment of ulcers and other diseases of patients. Their results revealed that *O. sanctum* extracts have specific cytotoxic activities against specific cell lines and that they are not generally cytotoxic.

In an investigation it is concluded that *O. basilicum* extracts have the potency to act as powerful antioxidants and protect against DNA damage and have cytotoxic activity against MCF-7 cell line (Al-Ali et al. 2013). Yucharoen *et al*. (2011) in their research mentioned about the cytotoxicity of *Ocimum* species. The essential oil of *O. basilicum* showed cytotoxic action on cervical (HeLa), laryngeal and epithelial (HEp-2) cell lines (Kathirvel and Ravi 2012). In a work conducted by Fandohan et al. (2008) mentioned about toxic aspects of some *Ocimum* species. A recent report refers the anti carcinogenic effect of *Ocimum* (http[1]).

Jeurissen et al. (2008) concluded that the compounds in basil can exert protective effect in the human hepatoma cell line HepG2. Lantto et al. (2009) conducted studies on cytotoxicity of plant extracts from basil and have concluded with positive results. Lee et al. (2005) states about the antioxidant properties of *O. basilicum*. Toxicity of compounds in essential oil of basil against stored rice pests were studied by Lopez et al. (2008). Earlier reports had proved that basil essential oil components like eugenol (Maralhas et al. 2006) linalool and myrcene (Mitic-Culafic et al. 2009) exhibits potential genotoxicity were reported.

Cytotoxic activity of *O. basilicum* is revealed by Suarez et al. (2013). The aqueous extract from the leaves of *Ocimum suave* was evaluated for acute and sub chronic toxicity and teratogenic effects and it was found that *Ocimum suave* is non toxic in acute and sub- chronic intake (Tan et al. 2008). Protective effect of basil (*O. basilicum*) against oxidative DNA damage and mutagenesis was evaluated by Beric et al. (2008).

Kusumaran et al. (1998) showed the effect of *O. sanctum* extract on chemical carcinogens. Leaf extracts of *O. sanctum* protected rats from deleterious effects of carcinogenesis. The aqueous extract of *O. gratissimum* was toxic to cell division and chromosomes only at concentrations below 10%. The effects of the extract of *O. gratissimum* in inhibiting and promoting cell division at certain concentrations and causing non-dose dependent chromosomal aberrations in the tested mice suggested its weak cytogenotoxic effects (Akinboro et al. 2013).

Nagaprashantha et al. (2011) conducted to determine the efficacy of novel flavonoid vicenin-2 (VCN-2), an active constituent of the medicinal herb *O. sanctum* in combination with docetaxel (DTL) in carcinoma of prostate. The study revealed that VCN-2 effectively induced anti-proliferative, anti-angiogenic and pro-apoptotic effect in CaP cells (PC-3, DU-145 and LNCaP) irrespective of their androgen responsiveness or p53 status. It was observed

in another study (Jha et al. 2012) that the treatment of a squamous cervical cancer cell line, SiHa with the ethanolic extracts of leaves of *O. sanctum* at IC50 values for 48 h resulted in the formation of internucleosomal fragments of DNA. Because of its anti- inflammatory, anti-proliferative and anti- angiogenic effects, *O sanctum* proves to be effective in cancer treatment.

The results of the studies by Banu et al. (2008) concluded that post arsenic administration of *O. sanctum* has significant role in protecting animals from arsenic-induced oxidative stress and in the depletion of arsenic concentration.

Uma et al. (2013) conducted toxicity assessment of the aqueous leaf extract of *O. tenuiflorum* in Wistar albino rats at different dose levels. Chronic administration of aqueous leaf extract of *O. tenuiflorum* shows no significant adverse effects on the parameters such as haematological, biochemical and also body weight changes. The levels of the marker enzymes in the vital organs were also found to be normal. Histopathological studies also showed appearance of normal architecture of the vital organs of the *O. tenuiflorum* treated rats and did not induce any toxic effects at different doses.

Studies have shown that eugenol, main component of many *Ocimum* species serve as an antimutagen (Miyazawa and Hisama 2003) and was found to inhibit carcinogen-induced genotoxicity (Han et al. 2007).

Toxicity and gastric tolerance of essential oils from *O. gratissimum* and *O. basilicum* in Wistar rats was studied by Fandohan et al. (2008). A dose-dependent effect of the tested oils was observed during the study, but administration of *O. gratissimum* oil did not result in adverse effects in rat liver at the tested doses.

Oral and intraperitoneal acute toxicity and the chronic intraperitoneal toxicity of the essential oil of *O. gratissimum* were investigated. A dose dependent sedative effect of *Ocimum* oil was observed during the acute toxicity study in mice and rats and in the subchronic test in mice and rats (Prabhu et al. 2009).

Bhuvaneswari and Jegatheesan (2011) from their study concluded that *O. sanctum* prevent the toxicity effects of carbon tetra chloride in rats. Another study suggests that the aqueous extract of *O. sanctum* controls the damage caused by mercury induced toxicity in Swiss albino mice (Sharma et al. 2002), lead toxicity on hepatocytes membrane and provides a

prognostic value with hepatoprotection (Akilavalli et al. 2011). Oral administration of *Ocimum sanctum* extract provides significant protection against cadmium induced toxicity (Ramesh and Satakopan 2010), lead poisoning (Karamala et al. 2010) in Wistar albino rats**,** benzene-inducced hematotoxicity in mice (Saha et al. 2012), endosulfan induced immunotoxicity (Bharath et al. 2011) and $HgCl_2$ induced toxicity in Swiss albino mice (Sharma et al. 2002).

Adedosu (2012) studied the effect of methanolic leaf extract of *O. gratissimum* on sodium arsenite-induced toxicity in rats. Histopathological studies on the toxicity of *O. gratissimum* leaf extract was conducted on some organs of rabbit and the end result provided evidence for nontoxicity of the above mentioned plant extract (Effraim et al. 2003). In a different experimentation, Ajibade et al. (2012) concluded that high doses of aqueous extract of *O. gratissimum* may have some adverse effects on the liver of adult Wistar rats, which may ultimately impair hepatic functions.

The antioxidant activity of *O. sanctum* is evident from its effectiveness in scavenging the free radicals in a dose dependent manner. It also possesses significant antipyretic, analgesic and antiarthritic activity without any noticeable toxicity (Singh 1996). Acute oral toxicity study of roots of *Ocimum sanctum* did not exhibit any lethality or any profound toxic reactions and is found to be safe (Boga et al. 2014).

Although there are limitations in extrapolation of bacterial antimutagenicity data on mammalian cells, the study conducted by Stajkovi et al. (2010) clearly demonstrate antimutagenic potential of basil derivatives and prove essential oil from basil and its components to be promising candidates for future antimutagenicity and anticarcinogenicity studies. It is however necessary to stress out that the results demonstrates the co-mutagenic effect of linalool with B(a)P. This together with literary findings, indicate that uncontrolled consumption of basil might be dangerous under certain environments rich in aromatic hydrocarbons.

Pingale et al. (2010) reported that there was no mortality recorded even at the highest dose level *i.e.* 7g/ kg body weight, which proves that *O. sanctum* leaf powder do not have any significant toxic effect in mice.

Vicenin, a flavonoid obtained from *O. sanctum* shows reduction in the percentage of aberrant cells and had no systemic toxicity (Devi et al. 1998). This report suggests a high toxic effect of the Western Cameroon *O. gratissimum* based on statistical prediction. Further predictions will be done using OpenTox, software which take into account the false negative and false positive predictions **(**Hzounda et al. 2011).

Toxicity of essential oils from *O. gratissimum* were tested against the rust-red flour beetle (*Tribolium castaneum* Herbst) (Coleoptera: Tenebrionidae) and concluded that toxicity was positively correlated with the concentration (Andronikashvili and Reichmuth 2003).

Sweet Basil (*O. basilicum*) oil have antiproliferative activity with the IC50 value of 0.0362 mg/ml (12.7 times less potent than 5-FU) in P388 cell line. The results demonstrated the potential of essential oil from Thai medicinal plants for cancer treatment (Manosroi et al. 2006).

Cytotoxic study was carried out on oleanic acid isolated from leaves of ethanolic extract of *O. gratissimum*. Effective dose of the compound at 50% concentration (ED50) was tested against a panel of human solid tumor cell lines *viz.*, human lung carcinoma (ED50 3.16 g/ml), human breast carcinoma (ED50 2.46 g/ml), human colon adenocarcinoma (ED50 3.12 g/ml), human renal carcinoma (ED50 3.13 g/ml), human prostate adenocarcinoma (ED50 2.58 g/ml) and human pancreatic carcinoma (ED50 3.47 g/ml) and concluded with satisfactory results that the extract have cytotoxic potential (Njoku 1997). Prabhu et al. (2009) tested the essential oils isolated from the leaves of *O. gratissimum* for their cytotoxic activity against P388 leukemia cells and was found to be cytotoxic.

The extract of *O. sanctum* was found to be genoprotective in *in vitro* tobacco extract induced genotoxicity. However, in the case of spontaneous genotoxicity in occupationally exposed *bidi* (tobacco) rollers, the difference between the *in vitro* treated and non-treated cultures was non significant. It infers that *O. sanctum* may have a genoprotective role and may not have a therapeutic role (Shukla et al. 2011).

The aqueous extract of *O. americanum* leaves at doses of 200 and 400 mg /kg have significant hepatoprotective ability against paracetamol induced hepatic damage in rats (Aluko et al. 2013)**.** The essential oil of *O. basilicum* shows cytotoxicity againsthuman cervical (HeLa), laryngeal and epithelial (HEp-2) cancer cell lines (Kathirvel and Ravi 2012).

Anti-genotoxic effect of *O. sanctum* on fluoride induced genotoxicity and its impact on oxidative stress had been attempted recently. They concluded that the beneficial effect of *O. sanctum* is possibly due to the synergistic action of contents like polyphenols, triterpenoids and flavonoids (Srilatha et al. 2013)**.**

Akinboroa et al. (2013) experienced the potential effects of aqueous extract of *O. gratissimum* on cell division, chromosome structure and sperm morphology in mice. Their observations suggest the possible mutagenic activity of the aqueous extract of *O. gratissimum* in albino mice.

The anti-genotoxic effect of *O. sanctum* L. extract was studied against the genotoxicity induced by a synthetic cyproterone acetate, on human lymphocytes using chromosomal aberrations, mitotic index, sister chromatid exchanges and replication index as parameters (Siddique et al. 2007). A clear dose-dependent decrease in the genotoxic damage of cyproterone acetate was observed, suggesting a possible modulating role of the plant infusion. The results of the study suggest that the plant infusion as such does not have genotoxic potential, but can modulate the genotoxicity of cyproterone acetate on human lymphocytes in vitro.

Vijaya et al. 2013 identified the antigenotoxic effect of *O. sanctum*. They tested the antigenotoxic effect of bio-synthesized silver nanoparticles of *O. sanctum* leaf extract on human lymphocytes against cyclophosphamide by using chromosomal aberration assay (CAA). The bio-synthesised SNPs of *O. sanctum* leaf extract were found to be a powerful genoprotectant.

Al-Ali et al. (2013) in their effort revealed the cytotoxic activity of *O. basilicum*. Siddique et al. (2006) pointed out that pharmacologically active compounds of *O. sanctum* like eugenol, rosmarinic acid and epigenin are excellent antioxidants. Flavonoids, orientin and vicenin have shown to possess protective effect against radiation induced genotoxic damage in cultured human lymphocytes by scavenging free radicals.

Fig. 1 Habit of some species of *Ocimum* (a) *O. basilicum* L. (b) *O. basilicum* var. *purpurascens* Benth. (c) *O. filamentosum* Forssk. (d) *O. gratissimum* L.

CONCLUSION

Herbal anti-cancer compounds are unique in their feature of having anti-oxidant and immune stimulant activity preventing cancer growth indirectly along with a direct cytotoxic effect towards malignant and/or other apoptotic cells. The induction of apoptosis is known to be an efficient strategy for cancer therapy. In this review it was found that the anticancer property of *Ocimum* attributed may be because of its cytotoxic effect. There is a need for a closer look at the genotoxicological effects of the tested extracts in animal test systems for human welfare.

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